Hydrogeologic Evaluation
Southport Subdivision

Rochester, Minnesota

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Public Works Department
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October 2002

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1.0 INTRODUCTION

The City of Rochester (City) is in the process of designing public sanitary sewer and watermain extensions to the Southport Subdivision (Southport). The extension of public utilities is being considered in accordance with the City's Water Quality Protection Program. Technical considerations for the extension include practical issues such as construction needs and cost analysis. Residents of Southport have specifically requested that the City also evaluate issues regarding surface water drainage and shallow ground water within the subdivision. Earth Tech, Inc. (Earth Tech), has been retained by the City to define the hydrogeologic conditions in the vicinity of Southport by assembling and reviewing existing information.

1.1 SITE DESCRIPTION

The Southport Subdivision is located in Rochester Township of Olmsted County. The project area occupies approximately 95 acres in the SE¼ of Section 13, Township 106 South, Range 14 West (Figure 1). The subdivision borders the southern boundary of the City of Rochester and is located along County State Aid Highway (CSAH) 1. The East Fork of Willow Creek flows along the western edge of the Southport Subdivision. The East Fork discharges into the main branch of Willow Creek at the northwest corner of the subdivision. Additional residential housing (the South Park subdivision) lies adjacent to the subdivision on the north and northeast. Willow Creek Middle School is also located along the northern boundary of the subdivision. A new housing development (Quinstar/Pinewood Hills) is currently under construction along the eastern and southeastern edge of Southport.

1.2 SITE HISTORY

1.2.1 Southport Development

Prior to the development of Southport as a suburban subdivision, the site contained a farmstead and was primarily used for animal grazing and cropland, as has been confirmed on a 1937 aerial photograph. E.J. Armit developed Southport in phases between 1956 and 1965. A total of 133 homes was constructed in Southport. Southport was not constructed with storm water management features such as curb and gutter or detention basins, however, a short segment of storm sewer was built along CSAH 1 at the northeast edge of Southport. According to the residents (see Appendix D), many of the homes were constructed with full basements using cement block walls. Since these homes were constructed outside City limits, they relied on individual sewage treatment systems (ISTS) and private wells.

Households in Southport obtain their water from both individual and shared private wells. Residents indicate that many of the homes constructed in the late 1950's were built with individual wells completed to an approximate depth of 60 to 70 feet with the wellhead penetrating the basement floor (see Appendix D). Records from these older wells are not available in the Olmsted County Well Index (CWI), compiled by the Minnesota Geological Survey. More recent records from the CWI, as shown in Table 1, indicate that wells installed in the early 1960's were drilled into bedrock and typically range in depth from 128 to 155 feet. Residents also indicate that these newer wells are located outside the homes and some are shared between multiple homes. Several residents with shallow wells terminating in their basements report that they experience artesian conditions in their basement wellheads several days following heavy precipitation and/or high creek levels.

The only major construction project that has occurred within Southport since the 1960's has been the construction of County State Aid Highway (CSAH) 1. This road, which extends north-to-south through

Southport, was widened in 1974 in conjunction with the upgrading and expansion of U.S. Highway 52. A review of Olmsted County's original construction plans (Olmsted County, Minnesota, 1973) identified the following design features of the CSAH 1 road construction project:

- The elevation of the road was to be lowered by approximately 1 to 3 feet.
- The road was to be widened from about 40 feet to about 75 feet.
- The roadway ditches were designed to primarily direct surface water flow toward the south, with a small portion of surface water routed toward the north on the very northern edge of the subdivision.
- The bottom elevations of the ditches on either side of the road were to be maintained at pre-construction elevations.
- A storm sewer was to be installed along the eastern side of the road between 26th Street and the northern boundary of Southport so that it would eventually discharge to the main branch of Willow Creek north of Southport.

"As built" documentation for the construction project was never prepared and was therefore unavailable for review to verify that these intended design features were achieved. One indication that the engineering design is not reflective of current conditions has been a land survey conducted by GGG, Inc., in 2001. The GGG survey shows that the entire east CSAH 1 ditch through Southport currently flows north rather than south, as designed. The cross-sections prepared by GGG indicate that the intended ditch profile planned in the 1974 construction design does not currently exist in the west ditch between 27th and 29th Streets. Furthermore, the City's 1999 aerial photography and digital contour maps show that both ditches flow north, at a 0.4 percent grade, except along the culvert at the south end of Southport, which drains the east road ditch toward the west, directly to the creek.

1.2.2 Neighboring Development

As mentioned previously, US Highway 52 was also upgraded in 1974. This included the reconstruction of the US 52 bridge over CSAH 1 to a higher elevation, regrading of side slopes, redesigned storm water control, and the expansion of the highway from two lanes to four lanes.

Residential and commercial development has occurred in the Willow Creek watershed outside of Southport over the past 40 years, such as the construction of the Willow Creek Middle School, Meadow Park, South Park, and the Quinstar/Pinewood Hills residential areas (located along 11th Avenue south of 16th Street Southeast), and commercial areas located along South Broadway Avenue. The current developed areas as illustrated in Figure 2 encompass about 12 percent of the Willow Creek Watershed. Storm water rate control facilities have been required by the City of Rochester to be constructed in new developments since the mid-1970s, depending on the accessibility to receiving waters and the conveyance capacity of the drainage ways. During the past 25 to 30 years, effective storm water management requirements have advanced to address additional water quality and quantity management criteria.

In the immediate vicinity of Southport, a drainage way was reconstructed in South Park (adjacent to the north half of the east side of Southport) in 2001 to improve the appearance and usefulness of the waterway, especially during low run-off periods. The storm sewer replaced a ditch that previously provided adequate transport of storm water. Additionally, two storm water ponds were constructed in 2002 for the adjacent Quinstar/Pinewood Hills development. The pond closest to CSAH 1 was constructed with a plastic liner to minimize infiltration to the water table.

1.2.3 Water Issues

In the summer of 1978, the Southport Subdivision reportedly experienced severe flooding, as did much of the Rochester area. The primary causes for the acute flood events were saturated soil conditions combined with multiple, high rainfall events. Residents commented that portions of Southport had 1 to 3 feet of standing water at this time, resulting in serious damage to homes and other property.

The City of Rochester undertook the South Zumbro River flood control project to minimize the infrequent but economically devastating effects associated with acute floods resulting from significant storm events. Two flood control structures were constructed during the mid- to late-80's as part of the overall flood control project that protect the southern half of the Willow Creek watershed from acute flood events: one reservoir was constructed on the main branch of Willow Creek and another was built on the East Fork of Willow Creek. The flood control reservoirs were designed to retain water from high precipitation events and spring snowmelt so that the water could be discharged more uniformly over an extended period of time. Based on information provided by Natural Resources Conservation Service (NRCS), the emergency spillway elevations ranged from 1,128 to 1,132 feet National Geodetic Vertical Datum (NGVD) and were designed to accommodate 100-year and 200-year storms.

The U.S. Army Corps of Engineers (USACE) indicated that flood control measures were also constructed on Bear Creek between 1993 and 1995 (Scott Jutilla, USACE, pers. comm.). Construction included the Bear Creek drop structure, which was constructed to prevent erosion at the end of the flood control project construction on Bear Creek due to the downstream widening and lowering of the creek. During baseflow conditions, some ponding upstream of the drop structure could be expected, but the upstream influence of the drop structure would be limited to that portion of the stream reach within about a 10-foot elevation change.

Based on the City's digital 2-foot contour map (see Figure 8), the elevation at the drop structure is about 997 feet and the confluence of Willow and Bear Creeks is at approximately 1,002 feet. The confluence of the West Tributary of Willow Creek and the main branch of Willow Creek is at about 1,012 feet, while the confluence of the East Fork of Willow Creek and the main branch of Willow Creek is approximately 1,017 feet. Because the elevations of the East Fork of Willow Creek around the north and west border of Southport range from approximately 1,014 to 1,018 feet, the zone of influence of the Bear Creek drop structure expires before Southport during baseflow conditions, near the intersection of the creek with CSAH. Given the additional 10 feet of elevation increase between creek at the CSAH 1 bridge and the Willow Creek (main branch)/East Fork Willow Creek confluence adjacent to Southport, it is also unlikely that the zone of upstream ponding would reach Southport during high flow conditions.

Southport residents indicated that a private party dredged portions of Willow Creek prior to the mid-1980's. Residents also indicated that the East Fork of Willow Creek has historically been dry in response to seasons and during periods of low precipitation. In recent years, residents stated that the creek has not become seasonally dry (Appendix D). Conversely, the City received a request in August 2001 from an upstream farmer to increase the flow from WR-4 into the East Fork of

Willow Creek because the supply of water in the East Fork of Willow Creek was inadequate to provide drinking water for his cattle. Many residents of Southport have commented that they have noticed more chronic water problems within the last 5 to 15 years, despite efforts to raise homes and install individual home drainage systems.

1.3 OVERVIEW OF RELATED REGULATIONS

The Willow Creek Watershed overlies four political jurisdictions that independently administer zoning regulations: Rochester Township, High Forest Township, Marion Township (administered by Olmsted County using the Olmsted County Zoning Ordinance), and the City of Rochester. Two general categories of regulations exist to manage the impact of development as it relates to surface water flow: those that apply to geographic areas near waterways that are potentially impacted by flooding and those that deal with storm water and erosion control, regardless of the geographic location of the development. The specific language for the two types of regulations varies from jurisdiction to jurisdiction (and are included in Appendix A), as do the development plan review and enforcement procedures.

According to the staff of the Rochester-Olmsted Planning Department, storm water and erosion control regulations have been evolving over approximately the last 15 years. Developments, like Southport, that were constructed prior to the existence of these regulations, were not required to address storm water management.

None of the jurisdictions mentioned above has zoning requirements that address construction standards for areas with a high ground water table. The Minnesota Uniform Building Code (MN UBC), however, does address this issue in the 1997 MN UBC (Appendix Chapter 18, sections 1830, 1835, 1836, and 1837). Rochester and Olmsted County Building Codes adopt the MN UBC by reference.

1.3.1 Flood-Related Regulations

The flood-related regulations discussed below apply only to areas potentially impacted by flooding, that is, areas in close proximity to waterways, and do not apply to geographic areas outside the flood plain.

Different areas affected by flooding have specific definitions based upon Federal Emergency Management Agency (FEMA) Flood Boundary and Floodway Maps and Flood Insurance Rate Maps. The Flood Fringe Zoning District, Floodway Zoning District, and Flood Prone Zoning District guide development in the floodplain so that the potential for damages during flood events is minimized. Broadly, regulations associated with these three districts direct that:

- New structures have proper flood protection.
- Uses that are dangerous to health and safety during flooding are restricted or prohibited.
- The ability of flood waters to discharge through the flood plain is maintained.
- Loss of flood storage volume in the flood plain is reduced.
- Increases in downstream flood levels and velocity are avoided.

These regulations also identify permitted uses within the flood districts as those which have a low flood damage potential, do not obstruct flood flows, and do not adversely affect the capacity of the channel or floodways. The regulations further identify those activities for which conditional use permits must be obtained and the evaluation that must occur to determine that the activities will not increase the potential for damage during flood events.

Filling is not generally permitted within the Floodway District. Grading or filling in the Flood Prone or Flood Fringe Districts may not proceed without first obtaining all necessary permits and approvals and approved filling must be protected against erosion. Fill cannot obstruct the flow of floodwaters.

1.3.2 Storm Water-Related Regulations

Regulations for storm water and erosion control apply universally to construction projects within a jurisdiction's boundaries. In general, these standards are designed to:

- Prevent erosion and off-site transport of sediment.
- Restrict the discharge rate of storm water to pre-development conditions.
- Where possible, use existing natural features for storm water retention and/or detention before its discharge to public waters.
- Where natural features are inadequate to manage storm water, construct facilities to manage storm water before its ultimate discharge to public waters.

When developments are constructed, the amount of impervious surface increases, thus requiring management of surface water with the goal of transporting it to a natural waterway without adversely affecting the development or downstream property owners. The increase in impervious surface also results in reduced infiltration of surface water into the soil, and eventually to the water table.

Comprehensive storm water management planning takes into account the conveyance capacities of water control features such as wetlands, ditches, and waterways, as well as providing direction for the addition of constructed management features, where necessary. The City of Rochester has completed storm water management planning for the Willow Creek Watershed that will guide future City development in this area. This information is available for use by other jurisdictions within the Willow Creek Watershed, but the degree of erosion control and storm water management required by each of the four governmental jurisdictions currently varies due to the differences in the zoning requirements for each entity.

The Environmental Protection Agency has delegated the National Pollutant Discharge Elimination System (NPDES) permitting authority to the Minnesota Pollution Control Agency for erosion control and storm water management. The NPDES permitting program currently applies to certain industries and construction sites larger than five acres, regardless of other erosion and storm water controls provided by local jurisdictions. As of March 10, 2003, the NPDES permitting program will be expanded to include all construction sites one acre or larger, as well as to Rochester Township, the City of Rochester, and Olmsted County.

2.0 HYDROGEOLOGIC SETTING

Physiography (or physical geography), topography, climate, geology, hydrogeology, and local water usage information specific to the Southport Subdivision has been compiled, summarized, and evaluated from various publications, internet resources, and previous investigations. New investigations were not part of the scope to prepare this report.

2.1 HYDROLOGIC CYCLE

Fetter (1988) describes the hydrologic cycle as actually having no beginning or no end. As most water is in the oceans (97.2 percent), it is convenient to describe the hydrologic cycle as starting with the oceans. The hydrologic cycle can be summarized as follows:

Water evaporates from the ocean (and other surface water bodies) and evapotranspirates from plants (1)

⇓

Water vapor moves through the atmosphere (2)

⇓

Water vapor condenses and forms droplets (3)

⇓

Precipitation falls on the land surface (4)

⇓

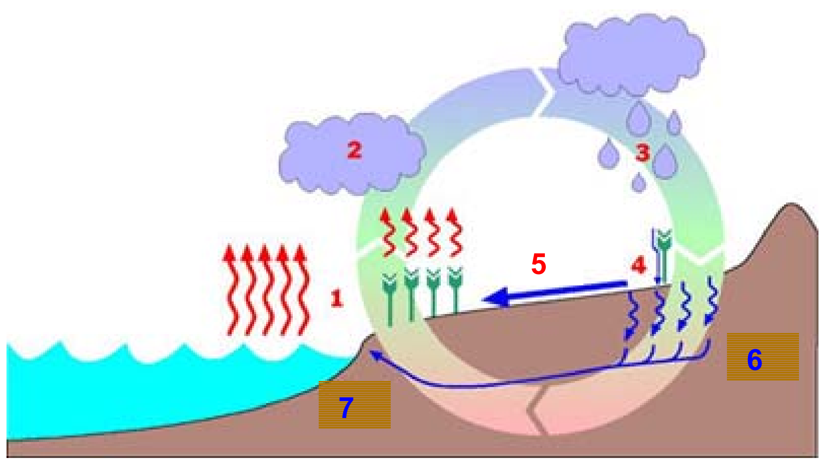
Surface water moves as overland flow (5) OR Surface water infiltrates through soil (6)
(streams and run-off) (ground water recharge)

⇓

Surface water reaches and ground water discharges into lakes, rivers, and oceans (7)

⇓

Water returns to the atmosphere (1)



In reference to the ground water conditions at the Southport Subdivision, the factors that directly influence the shallow ground water system are precipitation, overland flow, and infiltration. An additional localized source of water infiltration not addressed in the hydrologic cycle is that discharged by people. The water discharged via septic drain fields and sump pumps can also infiltrate to the water table. Based on the Minnesota Pollution Control Agency's Onsite Sewage Treatment Manual, the estimated sewage flow for an average three bedroom home would contribute 300 gallons of water per day. For the 133 homes in Southport, that equates to approximately 0.06 inches per day of wastewater that may be introduced to the water table through septic system drain fields. Water discharged from sump pumps and recirculated back to the water table cannot be quantified, but would also add water back to the water table.

2.2 CLIMATE

Anderson et al. (1975), reports the average annual precipitation for the Rochester area from 1940 to 1969 was 28 to 29 inches. Based on data provided by the National Weather Service on their website (www.nws.noaa.gov), the average precipitation for the Rochester area from 1961 to 1990 is 29.66 inches. Figure 3 illustrates the annual precipitation data collected by the National Weather Service for the City of Rochester for the 1950 to 2001 time period. Figure 3 indicates that the Rochester area has received above average precipitation (i.e., > 29.66 inches) during eight of the past 11 years. More specifically, precipitation amounts exhibit an increasing trend since 1950 of over 5 inches of increased rainfall on an annual basis. Significant precipitation (i.e., > 39 inches per year) was also received during the years of 1951, 1973, 1978, 1986, 1990, and 2001.

Observations by the State Climatologist are available on the Climatology Working Group website regarding *Minnesota's Precipitation Climate at the End of the 20th Century* (www.climate.umn.edu/doc/journal/wet1990s.htm). The observations include the fact that precipitation in the 1990's exceeded the climatological benchmark (1961-1990 normal) by a significant amount across much of Minnesota. In portions of southeastern Minnesota, the cumulative precipitation departure from normal is in excess of 40 inches from 1991-1999. The period 1977-1986 was also very wet when compared with the long-term data. Therefore, in spite of the 1976 drought and the 3- to 4-year drought of the late 1980's, the last 25 years in southeastern Minnesota were quite wet when compared with the first three quarters of the 20th century. The state climatologist goes on to note that the precipitation patterns are typical and should be "treated as an inherent component of a continental climate."

2.3 PHYSIOGRAPHY AND TOPOGRAPHY

Southport lies in the physiographic province designated as the Rochester Till Plain (Wright, 1972). The surficial soils were deposited during the glacial age and consist primarily of till (unstratified glacial deposits) and loess (soils deposited by wind). The Rochester Till Plain extends across the southeastern corner of Minnesota east of the City of Owatonna and south of the St. Paul-Minneapolis metropolitan area. The Rochester Till Plain is a nearly featureless surface of pre-Wisconsinan till with a partial cover of loess deposited during Wisconsinan time. The eastern part of the till plain is deeply dissected by tributaries of the Mississippi River, which expose flat lying Paleozoic Era sedimentary rocks. Willow Creek is one of these tributaries.

Figure 1 illustrates the topography of the subdivision and the adjacent development. Willow Creek and Southport lie within a valley at an approximate elevation between 1,025 and 1,035 feet NGVD with the walls of the valley and bedrock remnants occurring at ultimate elevations above 1,200 feet NGVD. The topography across Southport generally has very flat relief (Figure 4). The land gradually slopes toward the northwest where the East Fork discharges into the main branch of Willow Creek. Actual elevations range from 1,034 feet in the southeast to 1,020 feet along the northwest; a 0.5 percent grade. A ridge that rises to an elevation of nearly 1,100 feet is located approximately 750 feet east of Southport's eastern boundary.

2.4 SURFACE WATER HYDROLOGY

Southport lies within the Willow Creek watershed, a sub-watershed of the Zumbro River watershed (Anderson et al., 1975). The nearest perennial stream to Southport is the East Fork of Willow Creek, which borders the western edge of the Southport Subdivision and joins the main Willow Creek channel just northwest of the subdivision. Willow Creek discharges into Bear Creek approximately ½ mile north of the subdivision. Bear Creek discharges into the Zumbro River in downtown Rochester; the Zumbro River eventually discharges into the Mississippi River southeast of Wabasha, Minnesota.

As indicated by the topography, Willow Creek and its tributaries meander within a broad valley originally carved by glacial meltwater and later filled with glacial outwash sediment. The Willow Creek drainage basin covers approximately 17,000 acres (see Figure 2). Given the depositional environmental of the glacial outwash sediment, the broad channel appears to represent a stream terrace. This terrace can be defined as a level surface located above the current level of Willow Creek and represents the dissected remnants of an abandoned floodplain or streambed. Currently, the banks of Willow Creek appear to be somewhat unstable and easily eroded. Sloughing is evident on the banks where the predominant sediment consisted of fine to medium-grained sand.

The stream gauging station closest to the site is located at the CSAH 1 SE road bridge over Willow Creek. However, available data from the gauging station is limited to a handful of measurements in 1994 and, in the absence of a surveyed elevation reference point and stream profile, do not provide useful information in regards to the historical or current discharge capacity of Willow Creek.

As described previously, two flood control structures were completed several miles upstream on tributaries of Willow Creek in the mid- to late 1980's as part of the South Zumbro River flood control project. Based on information provided by the local NRCS, the emergency spillway elevations were designed to manage 100-year and 200-year storms that consist of 6 to 7 inches of precipitation within a 24-hour period. The 500-year storm elevations (nearly 8 inches of rain within a 24-hour period) would exceed the emergency spillway elevations by 1 to 2 feet. The 100-year and 500-year floodplains in the vicinity of Southport have not been modified from the FEMA studies that began in the mid-1970's for flood insurance purposes because no physical change occurred to the channel within the floodway as a part of the flood control project. The current 100-year and 500-year floodplains are illustrated on Figure 4. Small portions of the Southport Subdivision encroach on both floodplains.

Based on the relatively flat site topography, as illustrated in Figure 4, minimal means to control or convey surface water drainage currently exists within Southport. As described in Section 1.2, shallow ditches are present along CSAH 1 SE, but their drainage profiles are too shallow to effectively manage the surface water runoff from the road. Only a limited length of storm sewer is available to transport surface water away from the yards of homeowners. Currently, there are few ditches along any of the side streets to help provide drainage and very few driveways are equipped with culverts to intercept and direct surface water. The new housing development to the east (Quinstar/Pinewood Hills) will be installing curb and gutter along with two storm water detention ponds that will split the discharge of the accumulated water. Run-off from approximately 27 acres will be directed to the north to the storm water drainage way and storm sewer along the Northeast side of Southport. The remainder of the drainage from Quinstar/Pinewood Hills (about 100 acres), along with drainage from areas upstream to the southeast of

Quinstar/Pinewood Hills (about 110 acres), will be routed west, directly to the East Fork of Willow Creek, through the CSAH 1 culvert located at the southern end of Southport. This split discharge is intended to mimic the existing watershed drainage conditions. According to City-approved General Development Plans, all post-development surface water run-off from the Quinstar/Pinewood Hills development east of Southport will be directed through storm water management ponds designed to limit flow to *less than* pre-development conditions. This goes beyond the standard City requirement to limit post-development flows so they equal pre-development conditions.

The National Wetlands Inventory (NWI) mapping indicates that wetlands are present adjacent to Willow Creek and its tributaries and extend into Southport as illustrated in Figure 1. NWI-identified wetlands were also noted on the valley wall east of the subdivision and are apparently fed by ground water seepage from the Decorah Shale bedrock contact. Mapping available from Olmsted County varies somewhat from the NWI mapping because it uses the presence of hydric soils as wetland indicators. County mapping does not indicate that wetlands conditions are likely present within the subdivision. It should be noted that the NWI mapping is primarily based on aerial photos and have not necessarily been confirmed through in-field investigations. Wetland conditions typically require water within 18-inches of the ground surface, along with the presence of hydric soils and wetland plant species.

2.5 GEOLOGY

Geologic conditions for the area have been defined based on publications and available boring and well data. Table 2 summarizes the information from soil borings conducted by American Engineering Testing, Inc. (AET) in July 2001 as part of the Water Quality Protection Program utilities extension project. Table 1 summarizes available data from wells installed in the subdivision obtained from the County Well Index (CWI). Table 3 provides data from water appropriation wells permitted by the Minnesota DNR. Table 4 summarizes available water level data from two piezometers located within Southport.

2.5.1 Bedrock Geology

The bedrock that underlies Olmsted County was deposited as shallow marine sediments during the Early Paleozoic era (Olsen, 1988a). The bedrock surface over most of the County consists of limestone, sandstone, and shale and is designated as Prairie du Chien Group and the overlying St. Peter Sandstone. If not eroded away, bedrock of the thinner, overlying Glenwood Shale, Platteville Limestone, or Decorah Shale may also be the uppermost bedrock within Olmsted County. An extensive network of valleys dissects the bedrock surface.

Beneath the subdivision, Olsen (1988a) indicates the uppermost bedrock unit is the Prairie du Chien Group. The overlying St. Peter Sandstone is the primary bedrock unit forming the walls of the Willow Creek valley. Based on available well logs in the vicinity of the subdivision, depth to bedrock locally ranges from 39 to 74 feet (Table 1), which corresponds to elevations between 951 to 981 feet (Appendix B). Olsen (1988b) indicates the bedrock surface decreases in elevation toward the west, indicative of the Willow Creek bedrock valley.

The Shakopee Formation makes up the uppermost bedrock unit within the Prairie du Chien Group and is typically a light brown to buff-colored, thin- to medium-bedded dolomite with thin interbeds of quartzose sandstone and shale. The overlying St. Peter Sandstone, where present, is bright white to light gray in color and consists of fine- to medium-grained friable, quartzose sandstone.

2.5.2 Glacial History

During the Pleistocene Epoch of Quaternary time, northern portions of North America underwent numerous glaciations. Four major glaciations are recognized in the upper Midwest, which are, from oldest to youngest, the Nebraskan, Kansan, Illinoisan, and Wisconsinan (Ojakangas and Matsch, 1982). Based on the Geologic Map of Minnesota: Quaternary Geology (Hobbs and Goebel, 1982), glacial drift in the Rochester area is associated with pre-Wisconsinan glacial deposits. However, the details of glacial activity during pre-Wisconsinan glaciations are obscured by erosion or burial beneath later deposits. Approximately 25,000 years ago during the Late Wisconsinan, much of the exposed pre-Wisconsinan deposits were eroded away (Hobbs, 1988). Hobbs (1988) indicates that the uppermost surficial deposits in the vicinity of Southport are alluvial terrace deposits (i.e., bank deposits originating from stream sediments) associated with Wisconsinan glacial meltwater streams. Ultimately, sediment derived from the eroded uplands and the melting Des Moines lobe overwhelmed streams, depositing the terraces present today.

2.5.3 Glacial Stratigraphy

Based on available CWI well logs (Appendix B), no deposits associated with pre-Wisconsinan glacial advances are present in this portion of Olmsted County. As described in the previous section, the thickness of surficial deposits locally ranges from 39 to 74 feet. Soil boring logs conducted by AET (Table 2) describe the uppermost soils as consisting of about 5 feet of brown, fine-to-mixed alluvium overlying more than 20 feet of coarse alluvium. Copies of the soil boring logs are included in Appendix C. Using the Unified Soil Classification System (USCS), the fine-to-mixed alluvium is typically classified as sandy lean clay (CL) and clayey sand (SC). The coarse alluvium is typically classified as silty sand with a little gravel (SM) and poorly graded sand with a little gravel (SP). The deposits appear indicative of a stream terrace.

2.6 HYDROGEOLOGY

Hydrogeologic conditions were evaluated using information from publications and available water level information from the vicinity of Southport. Bedrock and surficial hydrogeology are discussed in the following sections.

2.6.1 Bedrock Hydrogeology

The uppermost bedrock aquifer near Southport is the St. Peter-Prairie du Chien-Jordan Aquifer, which regionally can be up to 500 feet in thickness (Kanivetsky, 1988). The potentiometric surface (the height to which water would rise in a well) of the aquifer in the vicinity of Southport is at an approximate elevation of 1,020 feet, with ground water flow generally toward the north, converging toward the Zumbro River. In the absence of an overlying confining unit, the aquifer is largely unconfined in Olmsted County. No sinkholes or other karst features have been observed in the carbonate rock in the vicinity of Southport.

Ground water movement in the bedrock aquifer is a mixture of inter-granular percolation in sandstone and channeled flow in carbonate rock (i.e., limestone). Estimated yields (i.e., the volume of water that can be extracted) near Southport are very high, at greater than 1,500 gallons per minute. The DNR has issued water appropriation permits to a number of wells in a 3-mile radius (Table 3) that withdraw water from the Prairie du Chien and lower aquifers. There is no approved water well appropriation permits in the area to withdraw water from the St. Peter Sandstone or the surficial aquifer.

2.6.2 Surficial Hydrogeology

The glacially deposited stream terrace constitutes a surficial aquifer overlying the bedrock aquifer within the Willow Creek valley. Since the surficial aquifer is largely composed of sand and because there is no confining layer separating it from the lower bedrock aquifer, there is a direct hydraulic connection between the bedrock and surficial aquifers. Therefore, the bedrock potentiometric surface described above at approximately 1,020 feet is directly representative of water table conditions within the surficial soils.

Water level measurements were collected in July 2001 in the 23 soil borings completed by AET. Although permanent monitoring points are preferred (where water levels are allowed a longer period of time to confirm that equilibrium was reached), the available water level data was useful in estimating the static water elevation at each soil boring (Table 2). The estimated static water elevations were used to generate a conceptual water table contour map included in Figure 4. In general, the contours indicate that currently ground water flows toward the northwest across the subdivision at an approximate gradient of 0.005 ft/ft. Using an estimated hydraulic conductivity of 1×10^{-2} cm/sec and an estimated effective porosity of 20 percent, based on the soil types present beneath Southport, the average linear flow velocity is determined to be approximately 1 foot/day. As illustrated in Figure 4, the ground water flow direction becomes more westerly where the water table intercepts the creek, indicating ground water is discharging to the creek. This condition would be prevalent during periods of low flow within the creek (hence, a gaining stream). During periods of high flow within the creek (i.e., flooding conditions), the creek would be referred to as a losing stream where the water levels in the creek would be higher than the water table, allowing the creek to recharge the ground water (i.e., ground water contours would locally decrease away from the creek). The elevation at which a stream changes from being a ground water discharge point to a ground water recharge feature fluctuates based on the relative elevations between the water table and the creek level at any given point in time. The distance inland from the creek that either effect (gaining or losing stream) extends and its duration are unknown (see Figure 7).

In 1993, the DNR installed two, 1-inch inner diameter water level piezometers within the subdivision. One is located at 1406 25th Street Southeast (West) and the other is located at 1806 26th Street Southeast (East). Available water level information collected in 1994 and 2001 is presented in Table 4 and graphically illustrated in Figures 5 and 6. Specific conclusions about long-term water table conditions cannot be established or confirmed with the available data. However, sufficient data exists to indicate the following:

- Static water elevations obtained from the soil borings taken in 2001 appear representative of actual conditions.
- Static water elevations in the East well are higher than the West well confirming ground water flow is toward the west.
- From April to December 1994, water levels varied by less than 2 feet in both wells.
- From June to August 2001, water levels varied by nearly 4 feet in both wells.
- Seasonal fluctuations are evident in the 2001 data from both wells.
- Only the East well exhibited seasonal fluctuations during 1994.

- The highest recorded elevation in the West well in 1994 was 1,017.49 feet; the highest recorded elevation in the West well in 2001 was 1,020.12 feet.

- The highest recorded elevation in the East well in 1994 was 1,020.34 feet; the highest recorded elevation in the East well in 2001 was 1,022.33 feet.

3.0 DATA EVALUATION

Based on the information provided in the above discussion, an evaluation of the hydrogeological conditions of the Southport Subdivision is presented below.

3.1 REGIONAL CONDITIONS

As described previously in Section 2.2, parts of southeastern Minnesota have received a cumulative precipitation departure from normal in excess of 40 inches from 1991 through 1999. In reference to the hydrologic cycle, an increase in precipitation over a large area will directly affect other portions of the hydrological cycle on a regional scale. Based on the increase in precipitation, an increase in run-off and stream flow would be expected to occur, along with a regional rise in the ground water table. From 1991 through 1999, Rochester received 22 inches of excess precipitation (in comparison to the NWS annual average of 29.66 inches). Furthermore, the annual precipitation received in the Rochester area has exhibited an increasing trend since 1950 (see Figure 3). Therefore, excess precipitation, at both the local and regional scale, is contributing to increased run-off volumes and ground water table elevations.

To properly identify ground water elevation trends, water table monitoring must take place in a consistent, ongoing manner and at a frequency that differentiates changes due to seasonal variability. Specific conclusions about long-term water table conditions with Southport cannot be established or confirmed with the available data (see Figures 5 and 6). The 1994 and 2001 water level difference can be directly related to long-term precipitation trends and seasonal precipitation events. However, the water table data from Southport does reflect the unconfined, potentiometric surface conditions of both the surficial and bedrock aquifers that occur throughout the region. The permeability of the surficial aquifer and its direct hydraulic connection with the underlying bedrock aquifer would allow ground water conditions to reach equilibrium conditions following seasonal and precipitation events, as well as reflect long-term trends.

3.2 WATERSHED CONDITIONS

The location of the Willow Creek watershed in reference to regional physiography (stream terrace and creek valley) and geology (bedrock valley) naturally promotes surface water drainage and ground water flow toward Southport. This convergence can be illustrated in several ways:

- Southport is near the downstream terminus of the Willow Creek watershed and is adjacent to the confluence of The East Fork of Willow Creek and the main branch of Willow Creek.
- Surface water run-off from the valley wall to the east drains west toward Southport.
- As illustrated in the Olmsted County Geologic Atlas (Kanivetsky, 1988), ground water from the bedrock aquifer flows beneath Southport toward the west discharging into the terrace soils of the Willow Creek watershed.

The Southport ground water map (Figure 4) indicates that the water table present in the surficial soils is at elevations that are consistent with the elevations of the water table in the underlying bedrock aquifer (Kanivetsky, 1988). This equivalence demonstrates that the bedrock ground water converges with the surficial aquifer flow beneath Southport.

The flood control reservoirs constructed on Willow Creek and its tributaries are designed to protect downstream residents, including Southport, from 100- and 200-year storm events, and to some extent from a 500-year storm event. Without flood control structures like the reservoirs, these types of storm events typically result in flood events of short duration, but ones that can be catastrophic due to their high velocities and high water levels. The flood control reservoirs are designed to store water from these intense storms so that it can be released at more consistent, lower flow-rates over an extended period of time. The NRCS designed base flow discharges from the reservoir to mimic natural, pre-reservoir conditions to minimize the impact on Willow Creek.

The effect of increased precipitation rates or of the reservoir-released water on water levels in Willow Creek and its tributaries cannot be differentiated. As previously discussed in Section 2.6.2, a stream can either be a location for ground water to discharge (termed a gaining stream) or the stream can discharge its water to the water table (termed a losing stream). The gaining or losing status of a stream can change over time and is dependent on the stream and the water table elevations relative to each other, which can dynamically change with time. When the water level within Willow Creek is higher than the ground water, it recharges the ground water. When the water level in the creek is lower that the water table, the ground water recharges the stream. In the absence of elevation data for the stream base along with a comprehensive stream and ground water level monitoring program, the exact recharge/discharge relationship between Willow Creek and ground water is unknown. However, since the reservoirs reduce the height of creek flows after major storm events, the potential for Willow Creek floodwaters to recharge ground water at these times is also reduced, thereby minimizing a subsequent rise in the water table from the creek after storm events.

The shape of a streambed is a function of multiple, related factors, such as: water volume, sediment loads, soil substrate, the land surface gradient (the change in elevation over a given distance), and water flow rates. The segments of the West Tributary of Willow Creek and the East Fork of Willow Creek closest to their confluence with Willow Creek exhibit tight meanders that have formed slowly over time due to the flat gradient (about 0.002 feet/foot). In these conditions, water moves more slowly allowing the deposition of sediment carried from upstream. Additionally, as the creek flows, it carves into the underlying sandy soils of the terrace deposits. Since these soils are not stable, they slough away from the banks and are also deposited in the stream. Over time, these natural forces can reduce the water conveyance capacity of the creek. Catastrophic flood events can periodically counteract this build-up to some degree by flushing accumulated deposits through the creek system. Although discharge capacity of streams can be measured, there is no data specific to Willow Creek and its tributaries available to compare historic and current discharge capacities.

The development of new urban areas results in an increase in the amount of impervious surfaces (such as roads, houses, and sidewalks) within a watershed. This will alter the infiltration locations, conveyance paths, and discharge locations within a drainage basin, but will not appreciably change the overall hydrologic balance on a watershed basis. Since impervious surfaces do not allow surface water to naturally infiltrate into soils, the water must be directed away from these structures toward natural or constructed detention areas or drainage ways. Ultimately, water is directed toward the water body that would have received surface water in undisturbed conditions. Today, discharge to the receiving water is most often managed by directing storm water to detention ponds that release the water at pre-development discharge rates so as to mimic pre-development conditions as closely as possible. To varying degrees, based on jurisdictional requirements, developments constructed in this area since the mid-1980's have been required to control surface water run-off to pre-development run-off rates. Southport was built prior to the implementation of storm water management requirements and, therefore, does not meet the above goals for its own neighborhood.

Urbanization also changes the topography of the landscape. Grading and filling activities take place that can alter the direction of surface water flow, particularly when conducted on a large scale. As with storm water management, grading activities may alter conveyance paths and site-specific conditions to some degree, but today's regulations require a watershed-based balance for adequate flood storage. As with storm water management, the preparation of grading plans is a fairly recent requirement (since the mid-1980's) and came after the construction of Southport.

3.3 LOCAL CONDITIONS

As described above, the shallow ground water system in the vicinity of Southport will be directly influenced by precipitation, overland flow, and infiltration. The proximity of the floodplain and the presence of hydric soils and wetlands in the vicinity of the site indicate that the water table is naturally shallow in the area, since it takes many years for wetland soils and vegetation to be established under the right hydrologic conditions. In other words, shallow ground water would be anticipated to be a natural condition in this area, as evidenced by these water storage features. The area has experienced an increase in precipitation and the water table appears to have risen as a result. During low flow stream conditions including reservoir discharge flows, ground water primarily discharges into Willow Creek and its tributaries. This low flow condition is shown in Figure 4, as evidenced by the ground water gradient sloping toward the creek. Given the close proximity of the water table to the ground surface, the gradient could be reversed for some unknown distance during high flow conditions in the creek.

The ability of Willow Creek to recharge ground water near Southport during high flow conditions is facilitated by the high permeability of the sandy terrace soils over which Southport was built. The permeability of those soils also allows rapid infiltration of surface water directly from the land surface, which also recharges the water table. Those residents whose basement wellheads experience artesian conditions several days following heavy precipitation and/or high creek levels confirm this hydraulic relationship. As the water table rises to above the basement elevation in response to increased infiltration, the fluid potential of the shallower residential wells eventually equilibrates to the same hydraulic head of the water table (Figure 7). In other words, the hydraulic head within the well will equal the water table elevation, which is above the elevation of the wellhead, and water will flow out of the wellhead. As the water table drops (during periods of low creek levels or reduced rainfall and infiltration), ground water discharges to the creek and the fluid potential in the well remains below the top of the wellhead.

Although difficult to quantify, localized mounding of the ground water can occur in the vicinity of septic drain fields, water discharged in yards from basements sump systems, or in the vicinity of unlined detention ponds, drainage ways, and ditches that allow seepage. However, because these systems are localized in the high permeability surficial aquifer, these sources of water are not believed to contribute to a regional rise in the water table. Mounding of the ground water would only occur locally and seasonally. In the case of Southport, localized mounding of the ground water can occur in any of the conditions listed above except detention ponds; no detention ponds are currently present within the subdivision. The effect of seepage from the construction of the lined detention pond in the Quinstar/Pinewood Hills development is not known. Because the nearest detention pond has been lined, seepage should only occur at a very low rate (e.g., 10^{-4} to 10^{-6} cm/sec) and minimize the potential for mounding.

Impervious areas and storm sewers prevent the natural infiltration of surface water to ground water within any given development or subdivision. In the case of Southport's nearest neighbors (Meadow Park, South Park, and Willow Creek Junior High), surface water from those locations is ultimately discharged to Willow Creek at points downstream of Southport. In the absence of those subdivisions, surface water would be more apt to infiltrate to become ground water, adding to the elevation of the water table in that area. It is difficult to estimate the impact of other upstream or downstream subdivisions and developments due to their distance from Southport and the lack of historic and current stream profile data.

Because the construction of Southport pre-dated requirements for storm water management controls and an overall grading plan, adequate surface drainage features are generally non-existent. Without a site-wide grading plan or storm water conveyance system, surface water cannot drain away from Southport. Instead, it ponds on the surface and eventually infiltrates directly through the sandy soils and exacerbates the high ground water conditions present today. Additionally, ground water pumped out of residential basements is discharged onto the lawns, where, in the absence of off-site drainage, it can re-infiltrate to become ground water once again. Some individual homeowners have complicated the water problems by placing structures in surface water drainage ways and discharging sump pump water off-site.

A deterioration of some aging cement block basement walls has been reported with visible water seepage into basements, particularly during seasonally high ground water levels (see Appendix D).

A concern has been raised regarding the effect of nearby rock blasting on ground water recharge. Blasting is sometimes used to create fractures in otherwise non-porous bedrock to improve fluid flow. Given the highly permeable nature of the terrace sands and the underlying bedrock, it is unlikely that blasting associated with nearby construction is adding to the porosity of the aquifer.

An additional concern has been the existence of abandoned and active open gravel pits near Southport. When excavation is completed below the water table, ground water seeps into the pit to form a pond. The existence of the gravel pit does not significantly affect the water level in it or the water table around it. If the pit were dug deeper, the elevation of the water surface would remain virtually unchanged. Because the ponds are, however, direct connections to ground water they could present opportunities for ground water contamination depending upon the activities surrounding them.

4.0 SUMMARY

This report has presented and evaluated available information on the hydrogeologic conditions in the vicinity of the Southport subdivision near Rochester. The Southport subdivision is experiencing separate, but related, ground water and surface water problems. Primary findings are noted below in order of significance:

- The physiographic and geologic conditions naturally promote surface water drainage and ground water flow toward Southport.

- Southeast Minnesota (including Rochester) has experienced significant, increased precipitation over the last ten years.

- Cumulative increases in precipitation are contributing to a rise in the water table as a direct *regional* response. (This is an additive effect to the permanent geologic conditions that direct surface and ground water flow toward Southport.)

- Within the subdivision, the surface topography and individual lot grading are inadequate to effectively convey surface water away from Southport homes and into Willow Creek. In the absence of adequate surface water drainage on each lot, the surface waters generated by increased precipitation directly infiltrate into the surficial soils especially within topographic lows.

- The flood control structures on Willow Creek and its tributaries protect Southport from significant flood events by storing and releasing water at a lower discharge rates. At base flow conditions, the discharge rate mimics pre-reservoir base flow conditions. Above base flow conditions, an increase in creek level from the reservoir versus that which is due to the above normal precipitation over the past decade cannot be differentiated.

- Development has resulted in an alteration of ground water infiltration locations, surface water conveyance paths, and flood storage locations within the Willow Creek watershed. These changes have the potential to be both beneficial and detrimental to Southport, but the specific positive and negative effects of these changes cannot be quantified.

- Willow Creek has the potential to recharge the water table under high flow conditions if the elevation of the creek is higher than the elevation of the water table. The elevation at which this occurs varies with time and is unknown, as is the distance inland from the creek this effect might be experienced.

- The degree to which sediment loads (due to construction run-off, agricultural run-off, street sanding, and creek bank instability) have altered stream discharge capacity over time is not known. Any sediment loading would not significantly affect the water table due to the high permeability of the terrace sands. Additionally, the volume of water held by the creek is insignificant compared to the volume of water in the aquifer.

5.0 CONCLUSIONS

A regional and natural rise in the ground water table can be expected in southeast Minnesota due to the above average rainfall received in the past decade. The geologic conditions surrounding and underlying the Southport Subdivision intensify the impacts of this climate change at this location. These natural conditions are virtually impossible to control on a local basis. Obtaining more local well data to substantiate seasonal and long-term trends in ground water table elevations specifically within the Southport subdivision would not alter the overriding impact of precipitation and geology.

Poor surface water conveyance exacerbates the higher water table problems by causing localized ground water mounding. Improving surface water drainage and/or the discharge capacity of Willow Creek will *not* resolve the ground water level trends associated with increased precipitation and existing geologic conditions.

The construction of flood control dikes along Willow Creek and its tributaries would *not* appear to be effective at protecting Southport from high water because the high permeability soils would allow water levels to readily equilibrate on either side of a dike.

Area residents can independently evaluate methods to minimize leakage into their basements such as alternate basement construction methods, water-proofing basement walls, or raising the base elevation of their homes. Additionally, if a subdivision-wide surface water management system to outlet the water away from the development is found to be technically and economically feasible, impacted homeowners could also evaluate the option of installing perimeter drainage systems. These options may help alleviate some short-term water problems but cannot eliminate long-term problems associated with increased precipitation and a geologic setting that results in a rising water table.

6.0 REFERENCES

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TABLES

TABLE 1

SUMMARY OF COUNTY WELL INDEX DATA
Southport Subdivision
Rochester, Minnesota

Unique Well Number	Date Drilled	Well Depth (feet)	Ground Elevation (feet NGVD)	Depth To Bedrock (feet)	Bedrock Elevation (feet NGVD)	Depth to Static Water Level * (feet)	Estimated Static Water Elevaiton (feet NGVD)	Aquifer
227630	10/3/1962	128	1020	39	981	N/A	N/A	Praire du Chien Group
227632	3/14/1962	138	1023	68	955	N/A	N/A	Praire du Chien Group
228118	9/5/1962	155	1028	72	956	6	1022	Praire du Chien Group
228119	5/5/1962	128	1030	59	971	N/A	N/A	Praire du Chien Group
228120	5/22/1962	130	1030	60	970	8	1022	Praire du Chien Group
228121	5/4/1962	130	1025	69	956	6	1019	Praire du Chien Group
228122	4/20/1962	128	1025	63	962	6	1019	Praire du Chien Group
228123	5/1/1962	138	1025	62	963	0	1025	Praire du Chien Group
228124	3/3/1965	137	1025	58	967	N/A	N/A	Praire du Chien Group
228125	3/6/1962	130	1023	65	958	0	1023	Praire du Chien Group
228126	2/6/1965	132	1025	57	968	6	1019	Praire du Chien Group
228127	8/28/1961	132	1025	65	960	N/A	N/A	Praire du Chien Group
228128	9/21/1962	130	1025	48	977	6	1019	Praire du Chien Group
228129	7/30/1965	160	1025	55	970	N/A	N/A	Praire du Chien Group
228173	3/21/1962	138	1025	63	962	8	1017	Praire du Chien Group
228174	8/9/1962	129	1025	74	951	N/A	N/A	Praire du Chien Group
401636	8/31/1984	270	1030	65	965	0	1030	Praire du Chien Group

Note: *As recorded during original drilling. Water level may be misleading due to the effects of drilling and the use of drilling fluids.

TABLE 2

SUMMARY OF SOIL BORING DATA

(Data collected by American Engineering Testing, Inc., July 2001)

Southport Subdivision

Rochester, Minnesota

Boring Number[1]	Suface Elevation (feet NGVD)	Soil Boring Depth (feet)	Approximate Depth to Water (feet)	Estimated Water Elevation (feet NGVD)
B-1	1021.9	20.0	6.7	1015.2
B-2	1023.0	20.0	6.1	1016.9
B-3[2]	1023.7	20.0	> 6	< 1017.7
B-4	1023.8	20.0	6.1	1017.7
B-5	1023.0	20.0	6.9	1016.1
B-6	1023.8	20.0	5.0	1018.8
B-7	1025.1	20.0	6.4	1018.7
B-8	1025.7	20.0	6.3	1019.4
B-9	1022.8	20.0	3.4	1019.4
B-10	1025.1	30.0	4.9	1020.2
B-11	1027.1	20.0	6.7	1020.4
B-12	1027.7	20.0	6.4	1021.3
B-13	1023.4	20.0	4.1	1019.3
B-14	1026.5	20.0	5.0	1021.5
B-15	1028.3	20.0	5.4	1022.9
B-16	1029.9	20.0	7.3	1022.6
B-17	1027.0	20.0	7.3	1019.7
B-18[2]	1027.6	20.0	> 6	< 1021.6
B-19	1032.0	20.0	5.4	1026.6
B-20	1030.9	20.0	5.5	1025.4
B-21[2]	1033.8	20.0	> 6	< 1027.8
B-22	1031.6	20.0	4.5	1027.1
B-23	1034.7	20.0	7.2	1027.5

Notes: (1) Soil boring locations illustrated on Figure 4.
(2) Borehole caved in before water level could be measured.

TABLE 3

SUMMARY OF DNR WATER APPROPRIATION PERMITS
(3-Mile Radius)
Southport Subdivision
Rochester, Minnesota

Permittee	Unique Well Number	Water Source
Associated Milk Producers	233030	Praire du Chien
Associated Milk Producers	228636	Jordan
Associated Milk Producers	228365	Ironton Galesville
Duane & Peggy Christian	NA	Willow Creek
Forest Hillwell	220683	Jordan
Franklin Heating Station	220664	Praire du Chien Franconia
Franklin Heating Station	220665	Praire du Chien St. Lawrence
Lenwood Heights	220687	Jordan
Mathy Construction Company	NA	NA
Olmsted County Public Works	220784	Praire du Chien St. Lawrence
Olmsted County Public Works	220785	Praire du Chien Eau Claire
Rochester Parks and Recreation	NA	Zumbro South Fork
Rochester Public Utilities	220625	Jordan Eau Claire
Rochester Public Utilities	220627	Jordan
Rochester Public Utilities	220628	Jordan
Rochester Public Utilities	220662	Praire du Chien Mount Simon
Rochester Public Utilities	220660	Praire du Chien Eau Claire
Rochester Public Utilities	220666	Praire du Chien St. Lawrence
Rochester Public Utilities	220675	Praire du Chien Eau Claire
Rochester Public Utilities	220681	Jordan Eau Claire
Rochester Public Utilities	161425	Praire du Chien St. Lawrence
Rochester Public Utilities	228168	Jordan
Rochester Public Utilities	434041	Praire du Chien Jordan
Rochester Public Utilities	409455	Jordan
Seneca Foods Corporation	242118	NA
St. Mary's Hospital	231890	Jordan

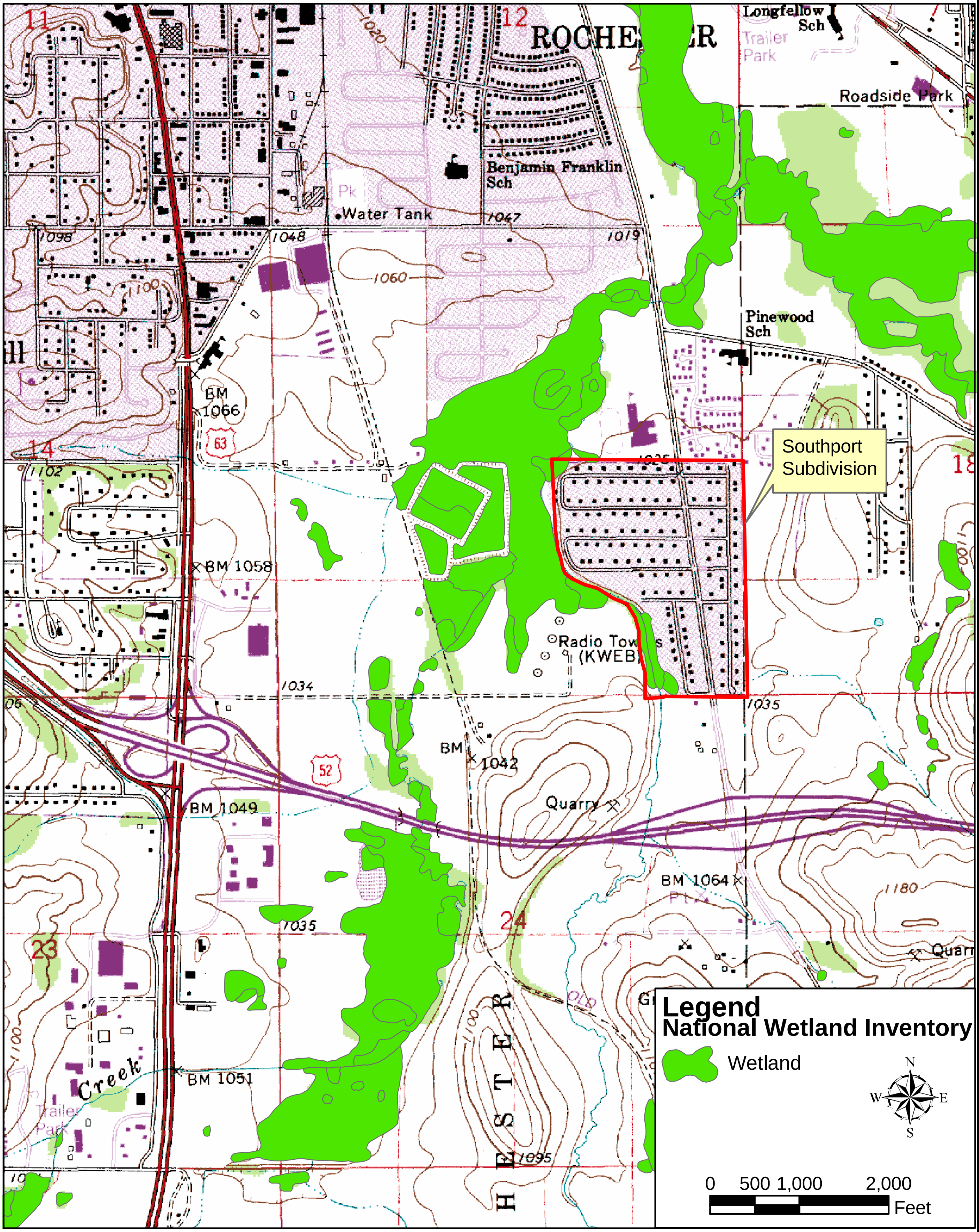
TABLE 4

SUMMARY OF WATER LEVEL DATA
Southport Subdivision
Rochester, Minnesota

Well Location	Top of Casing Elevation (feet NGVD)	Ground Elevation (feet NGVD)	Depth (feet)	Screened Elevation (feet NGVD)	1994 Static Water Elevations (feet NGVD)							
					4/1/1994	4/25/1994	6/3/1994	6/8/1994	8/25/1994	9/23/1994	10/6/1994	12/28/1994
West (1406 25th St SE)	1022.95	1022.4	8.7	1014-1016	1017.49	1017.45	1017.24	1016.95	1016.91	1016.93	1017.20	1017.10
East (1806 26th St SE)	1028.48	1025.2	11.3	1014-1016	1019.51	1020.34	1020.16	1020.20	1019.22	1019.30	1019.30	1018.62
Well Location	**Top of Casing Elevation (feet NGVD)**	**Ground Elevation (feet NGVD)**	**Depth (feet)**	**Screened Elevation (feet NGVD)**	**2001 Static Water Elevations (feet NGVD)**							
					6/16/2001	**6/17/2001**	**6/21/2001**	**6/25/2001**	**7/1/2001**	**7/13/2001**	**8/3/2001**	**8/10/2001**
West (1406 25th St SE)	1022.95	1022.4	8.7	1014-1016	1020.12	1019.62	1018.80	1018.05	1017.62	1016.95	1016.80	1016.37
East (1806 26th St SE)	1028.48	1025.2	11.3	1014-1016	---	---	1022.33	1021.93	---	---	---	1019.92

Notes: 1994 data collected by Minnesota Department of Natural Resources (DNR), Rochester Office.
2001 data collected by City of Rochester Public Works Department, Yaggy-Colby Assoc., and Carl Miller (local resident).

FIGURES



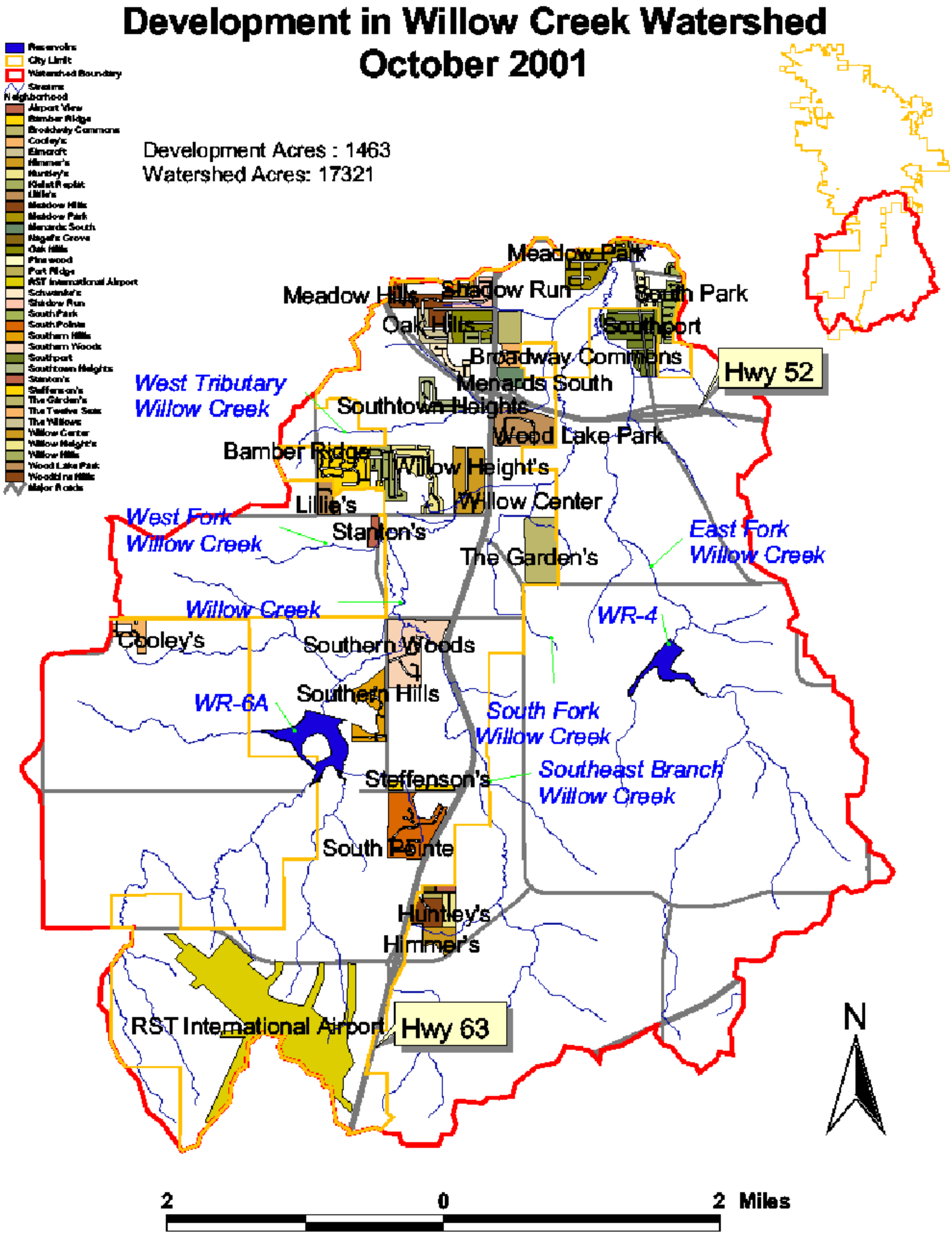
Source: USGS 7.5 Minute Topographic Map Simpson, Minnesota (1974), and NWI Coverage of Olmsted County.

EARTH TECH

FIGURE 1
USGS Topographic Map and NWI Wetland Map
Southport Subdivision
Rochester, Minnesota

October 2002

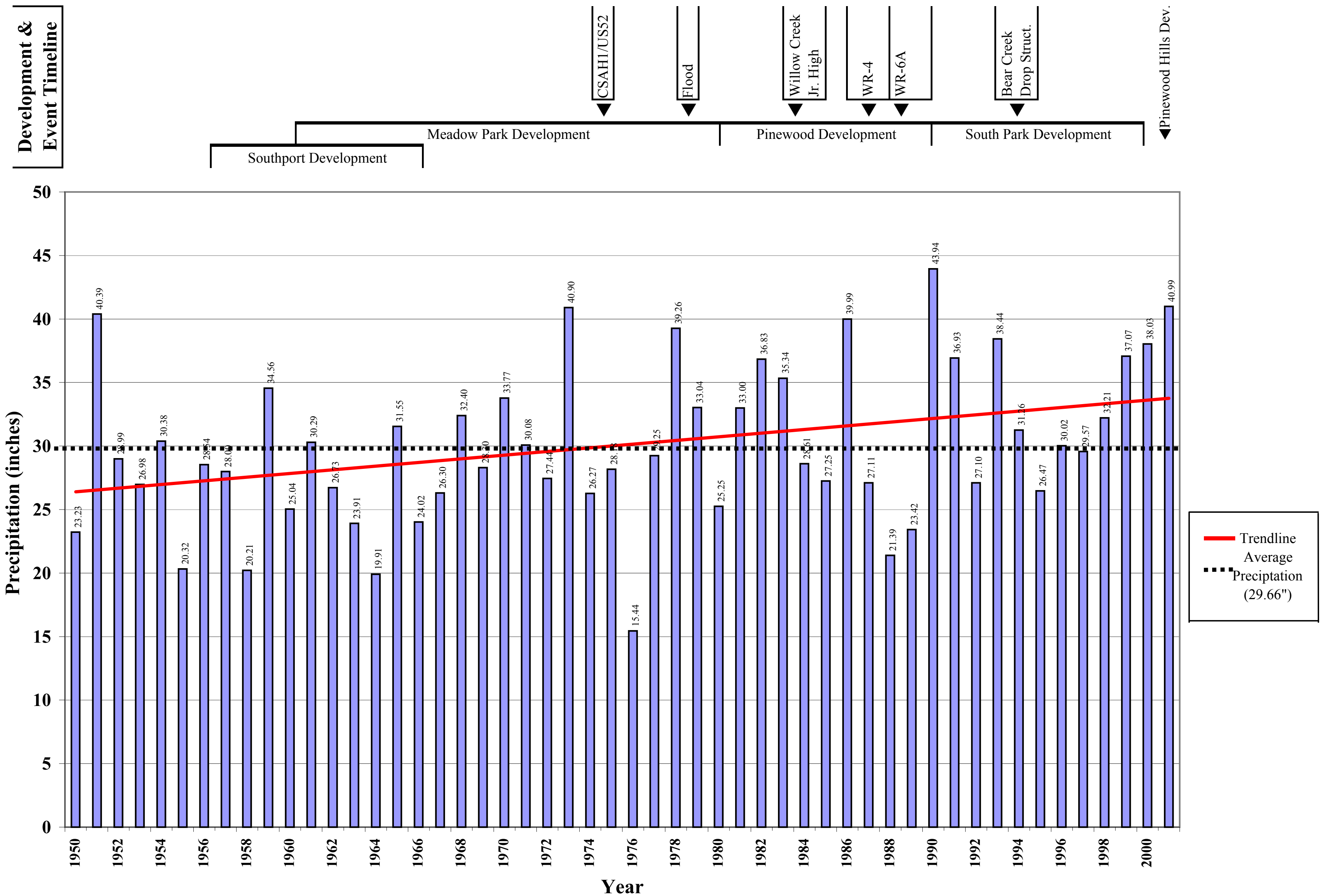
46529

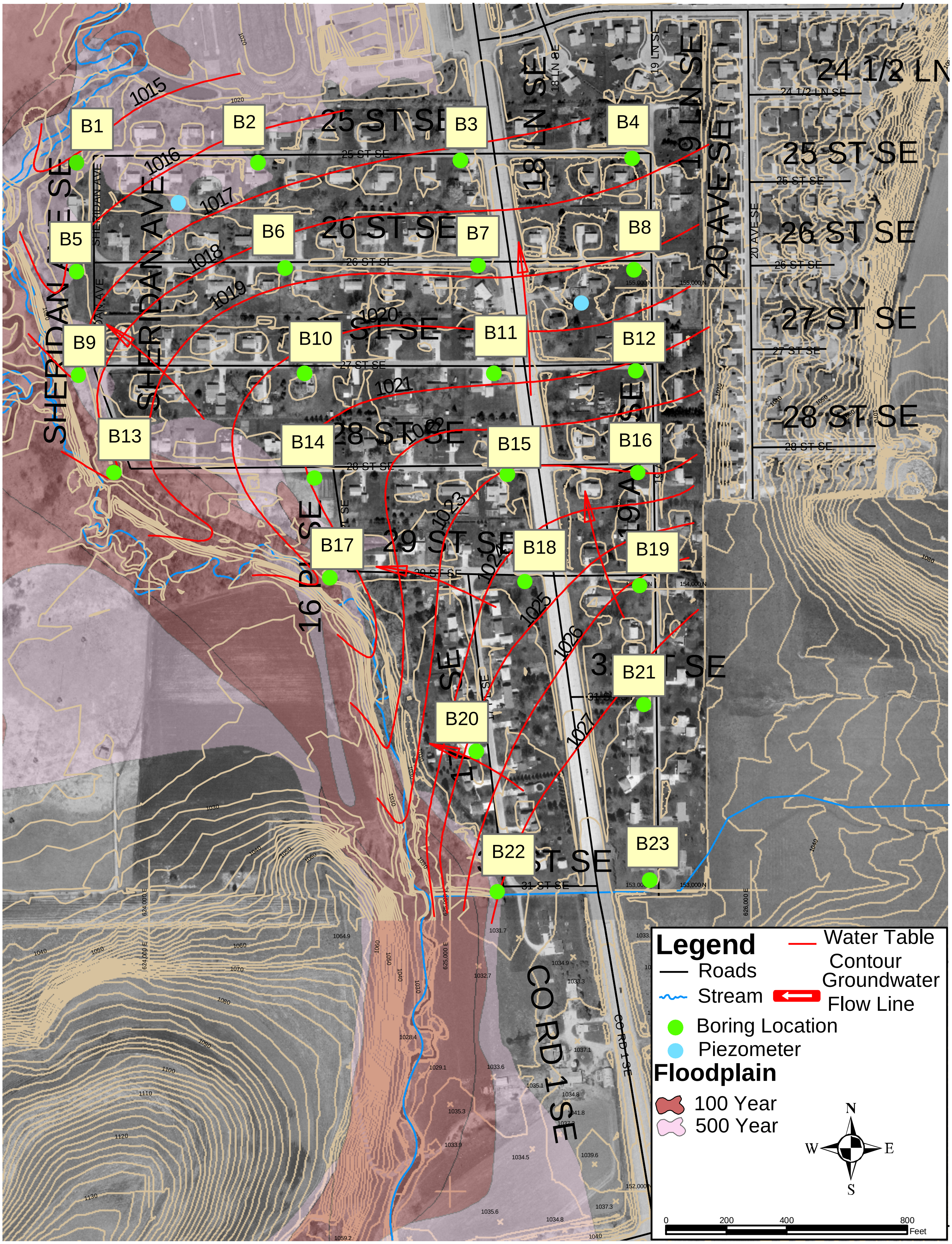


Source: Map adapted from information provided by the Rochester/Olmsted Planning Department GIS Division.

EARTH TECH	**FIGURE 2** Current Development Within Willow Creek Watershed Rochester, Minnesota October 2002 46529

FIGURE 3
Annual Precipitation (1950-2001)
Rochester, Minnesota





Source: Map adapted from information provided by the Rochester/Olmsted Planning Department Geographic Information Systems Division.

EARTH TECH

FIGURE 4

Topography, Floodplain, and Groundwater Contour Map

Southport Subdivision

Rochester, Minnesota

October 2002

46529

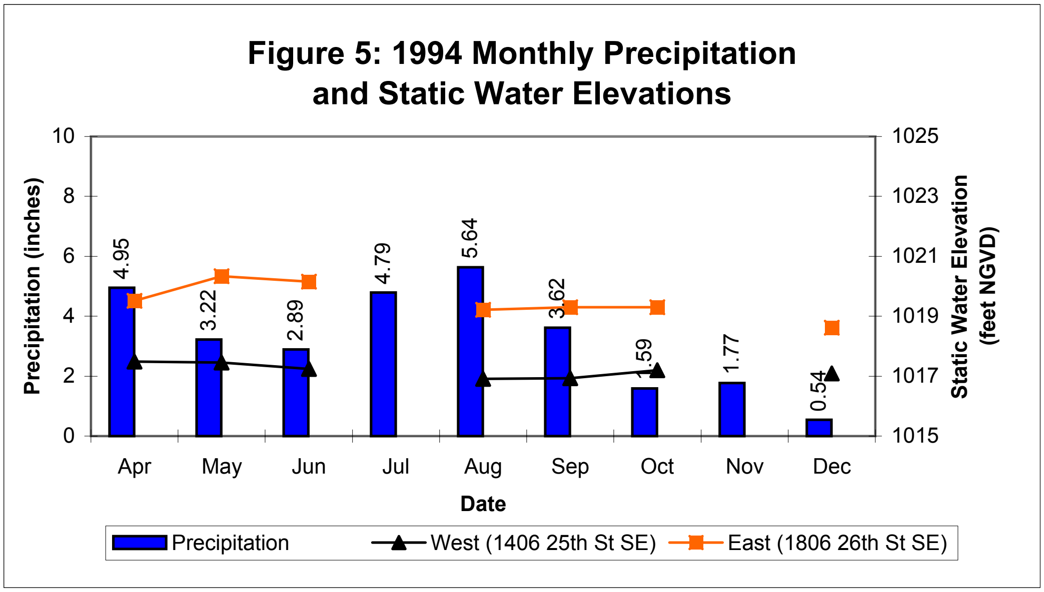


Figure 5: 1994 Monthly Precipitation
and Static Water Elevations
Precipitation (inches)
Static Water Elevation
(feet NGVD)
10
8
6
4
2
0
1025
1023
1021
1019
1017
1015
4.95
3.22
2.89
4.79
5.64
3.62
1.59
1.77
0.54
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
Precipitation
West (1406 25th St SE)
East (1806 26th St SE)

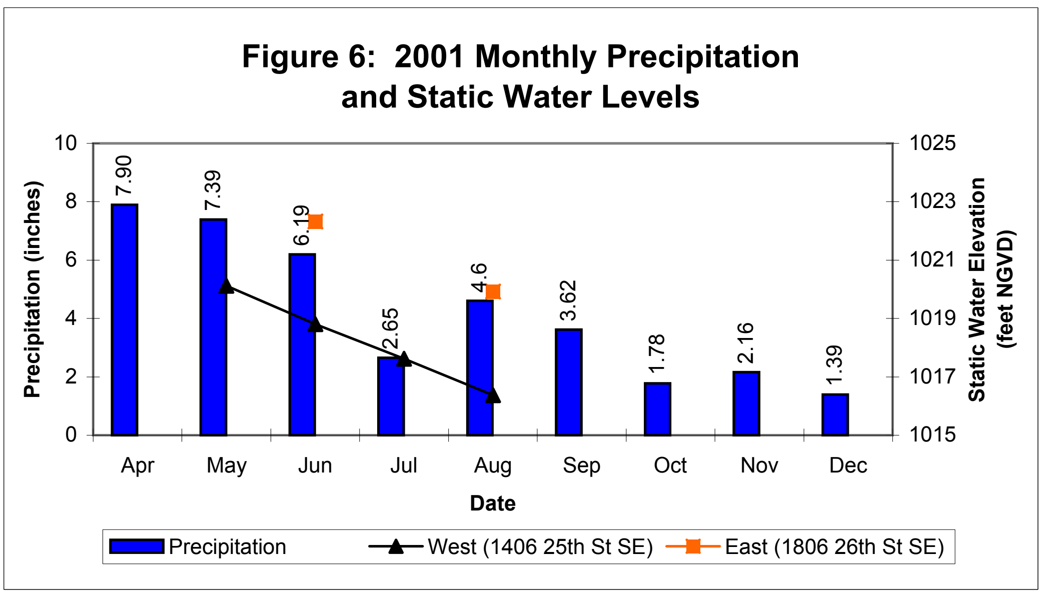
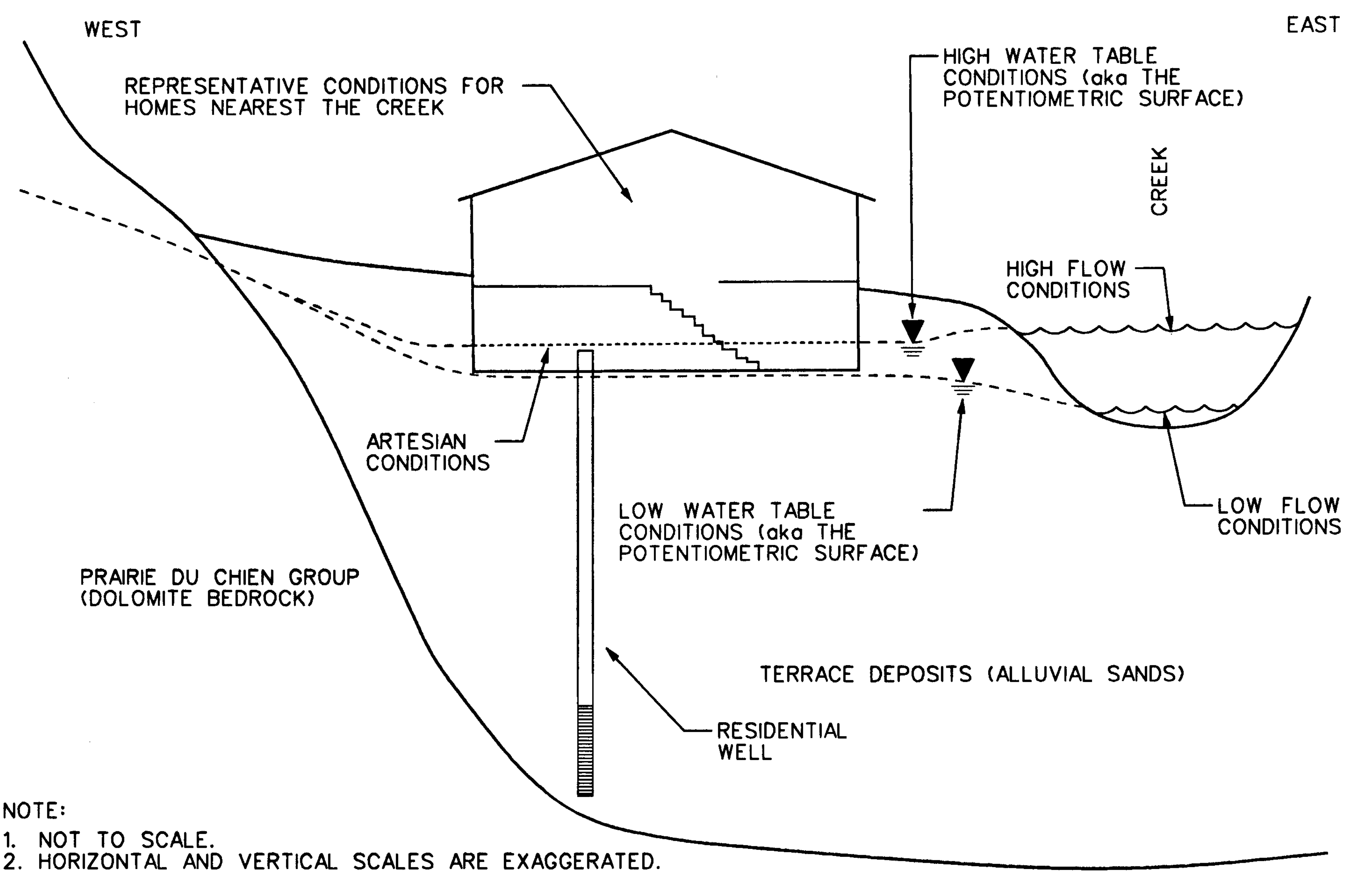


Figure 6: 2001 Monthly Precipitation
and Static Water Levels
Precipitation (inches)
Static Water Elevation
(feet NGVD)
10
8
6
4
2
0
1025
1023
1021
1019
1017
1015
7.90
7.39
6.19
2.65
4.6
3.62
1.78
2.16
1.39
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
Precipitation
West (1406 25th St SE)
East (1806 26th St SE)

DGN =I:\work\rochester\46529\cadd\cross_sec.dgn DATE =Tue Oct 29 14:32:55 2002



NOTE:

1. NOT TO SCALE.
2. HORIZONTAL AND VERTICAL SCALES ARE EXAGGERATED.

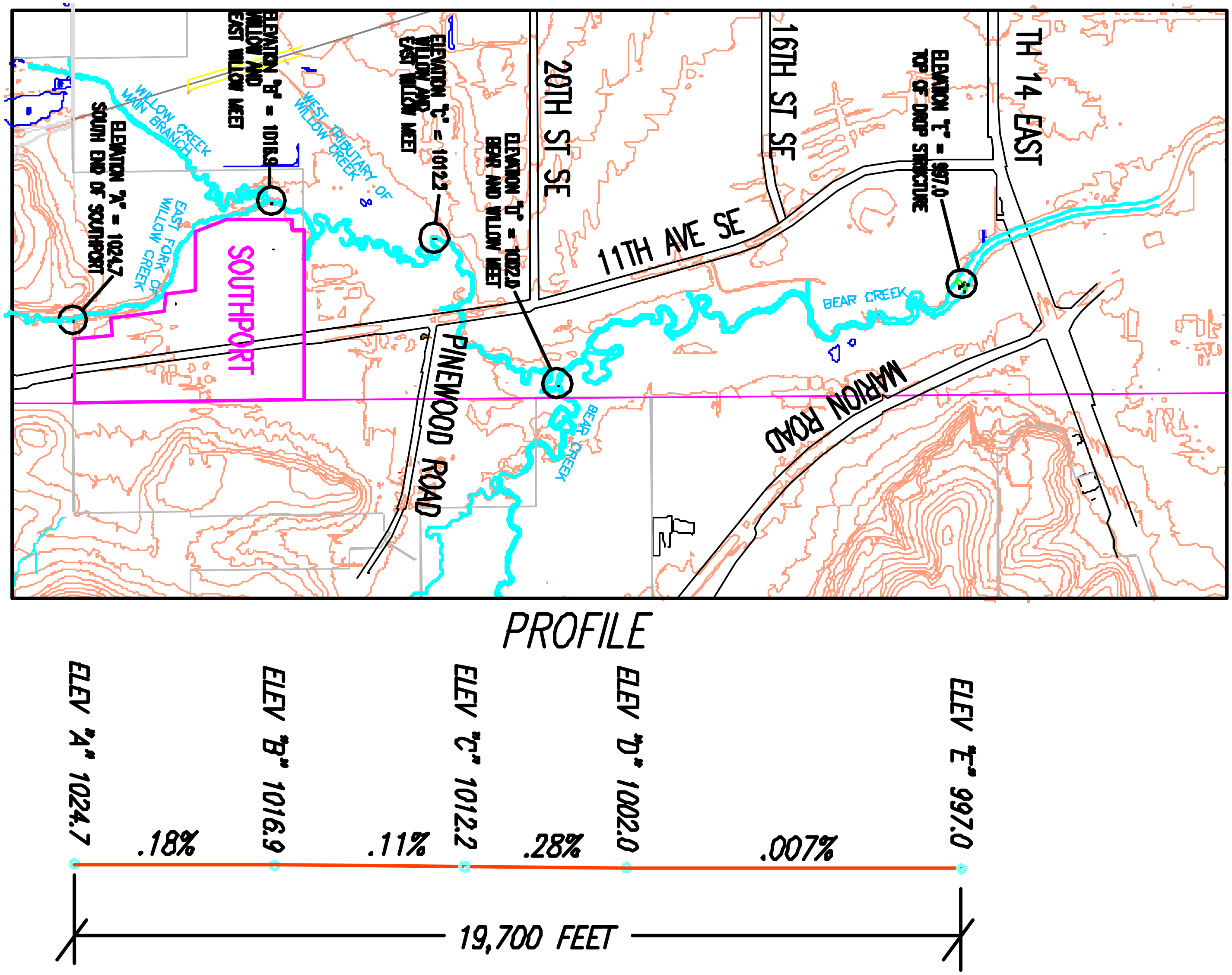
EARTH TECH

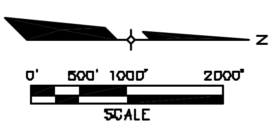
FIGURE 7

SCHEMATIC OF WILLOW CREEK WATERSHED CROSS-SECTION

SOUTHPORT SUBDIVISION
ROCHESTER, MINNESOTA

OCT 2002 46529





EARTH TECH

FIGURE 8
TOPOGRAPHY BETWEEN BEAR CREEK AND SOUTH PORT
SOUTHPORT SUBDIVISION
ROCHESTER, MINNESOTA

OCT 2002

46529

APPENDIX A

STORM WATER REGULATIONS

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City of Rochester Zoning Ordinance, Land Development Manual, and Building Code

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Olmsted County Zoning Ordinance

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High Forest Township Zoning Ordinance

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Rochester Township Zoning Ordinance

APPENDIX B

WELL RECORDS
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APPENDIX C

SOIL BORING LOGS
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APPENDIX D

SOUTHPORT SURVEYS AND MEETING MINUTES

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1993 Residential Surveys

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2001 Residential Survey Summary

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July 19, 2001, Residential Meeting Minutes